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WIREWORMS

on Irrigated Lands
in the West:

HOW TO
CONTROL
THEM

CONTENTS

	Page
Damage	1
Detecting and estimating wireworm populations	2
Description	3
Eggs	3
Larvae	3
Pupae	3
Adults	3
Life history and habits	3
Seasonal movements in the soil	4
Chemical methods of control	5
Precautions	5
Soil fumigation	7
Soil insecticides	11
Cultural methods of control	13
Water use	14
Cultivation	14
Rotation of crops	14

WIREWORMS DISCUSSED

- Sugarbeet wireworm (*Limonius californicus*)
- Pacific Coast wireworm (*L. canus*)
- Western field wireworm (*L. infuscatus*)
- Columbia Basin wireworm (*L. subauratus*)
- Great Basin wireworm (*Otenicera pruinina*)

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WIREWORMS ON IRRIGATED LANDS IN THE WEST: How To Control Them

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Growers of vegetable and field crops on irrigated lands in the West save millions of dollars annually by chemical and cultural control of wireworms.

Wireworms are the young (larvae) of click beetles. They live in soil and feed on underground parts of plants. They are recognized by their shiny, wirelike, yellow-orange bodies.

There are many kinds of wireworms in the West; five that cause most damage on irrigated lands are the sugarbeet wireworm, the Pacific Coast wireworm, the western field wireworm, the Columbia Basin

wireworm, and the Great Basin wireworm.

Only the Great Basin wireworm can live in nonirrigated soil where the precipitation is low. It gradually disappears during the first 3 or 4 years of irrigation. The other four wireworms live in irrigated soil. They usually appear 5 or more years after irrigation begins and may persist indefinitely.

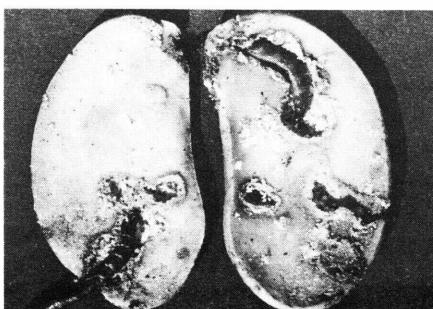
No crop is known to be free from attack by wireworms; crops particularly susceptible to attack are potatoes, onions, lettuce, melons, beans, tomatoes, peas, carrots, and sugarbeets.

DAMAGE

Wireworms damage crops in two ways. They kill seeds and seedlings, and they injure tubers, roots, and bulbs. Damage is most severe during cool, moist weather. Hot, dry weather causes wireworms to move down in the soil away from the most susceptible parts of plants.

Early in the growing season, wireworms reduce crop stands by eating seeds or by cutting off seedlings slightly below ground level.

If the damage is severe, replanting may be necessary (figs. 1 and 2). Later in the growing season, wireworms tunnel and scar maturing



TC-3830

Figure 1.—Wireworm damage on germinating lima beans.

¹This publication supersedes Farmers' Bulletin 1866, "Wireworms and Their Control on Irrigated Lands," by M. C. Lane (retired) and M. W. Stone (retired), Entomology Research Division.

tubers, roots, and bulbs (figs. 3, 4, and 5).

Although replanting is expensive, wireworm damage to tubers, roots,

and bulbs may result in a greater loss. A damaged crop must be destroyed or sold for feed at a low price.

DETECTING AND ESTIMATING WIREWORM POPULATIONS

Determine whether wireworms are present in your fields before planting. You can detect and count them by sifting samples of soil. If wireworms are found, you can either treat the soil or plant crops that are least damaged by wireworm attack. *The sooner wireworms are detected, the greater choice you will have in selecting a satisfactory control measure.*

Before getting your soil samples, be certain that the soil at the 6-inch depth is between 45° and 85° F. The first step in getting samples is to dig 20 well-scattered test holes per acre of land. Dig them with a 6-inch post-hole auger or irrigation shovel, and dig them 12 inches deep.

Soil samples can be examined for wireworms most easily by using a portable shaker and sifting tool (fig. 6). A 36- by 1½- by ¼-inch piece of spring steel serves as a flexible

pedestal. A disk welded near the bottom of the pedestal serves as a base, and a metal bracket welded to the top of the pedestal holds two sieves, or screens. The sieves are made by tacking wire screen to wood frames. The frames are made of 1- by 3-inch stock; they are 24 inches long and 24 inches wide.

Place 4-mesh (coarse) screen on one frame and 14-mesh (fine) screen on the other. The coarse screen will loosen the soil and separate plant debris and stones. Wireworms, if present, will fall onto the fine screen where they may be counted.

If no wireworms are found in the soil from 20 holes per acre, it should be safe to plant any crop. If five or more are found, damage to susceptible crops can be expected, and the soil should be treated with an insecticide.



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Figure 2.—Field of onions damaged by wireworms.

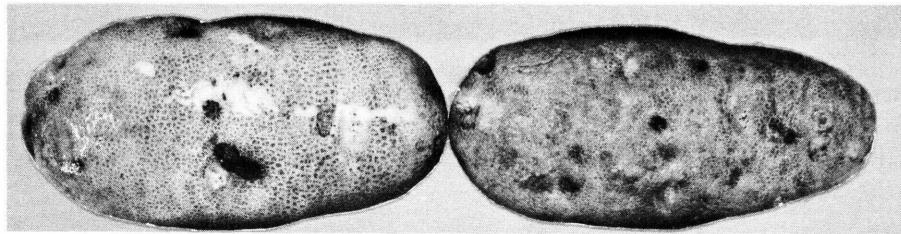


Figure 3.—Potatoes scarred by wireworms.

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DESCRIPTION

Eggs

Wireworm eggs are pearly white, nearly round, and about $\frac{1}{50}$ inch long.

Larvae

Newly hatched wireworms (or larvae) are white, have dark jaws, and are about $\frac{1}{16}$ inch long. After feeding and molting several times, they become hard, shiny, and dark yellow. They have three pairs of legs, and the last segment of their bodies is pronged or forked behind (fig. 7). Wireworms ordinarily seen in the soil are $\frac{1}{4}$ to $\frac{3}{4}$ inch long; these larger and older wireworms cause most damage to crops.

Pupae

The pupae (fig. 7) are white and very fragile. They resemble adult wireworms in size and shape, and become grayish or brownish just before reaching the adult stage.

Adults

The adults (fig. 7) are slender, hard-shelled beetles. They are tan to dark brown or black, and $\frac{1}{3}$ to $\frac{1}{2}$ inch long. They are popularly known as click beetles or snapping beetles, from their habit of snapping the forepart of their bodies when they are held between the fingers or placed on their backs.

LIFE HISTORY AND HABITS

The pupae transform into adult beetles in summer, but the adults do not emerge from the soil until the next spring, when temperature in the top 3 inches reaches 55° to 65° F. In southern California the beetles begin to emerge about March 1 and may continue to emerge until early May. In the Pacific Northwest they emerge from mid-April to early June.

The male beetles emerge and crawl about on the soil or rest on vege-

tation. On warm, sunny days they make short flights in search of females.

Female beetles emerge, mate, and immediately burrow back into the soil. They begin to lay eggs within a few days. After laying most of their eggs, they emerge again and make short flights, often to nearby fields, where they lay the rest of their eggs. This is the way infestations spread.

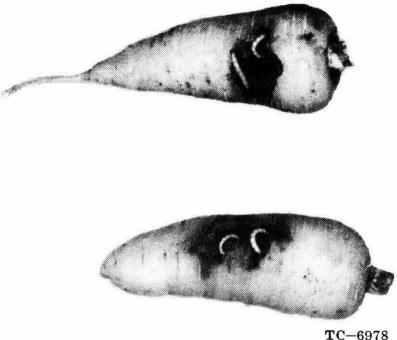


Figure 4.—Wireworms feeding on carrots.

Each female lays 50 to 350, or more, eggs. The eggs are placed close together, 1 to 6 inches deep in moist soil. They hatch in 3 to 4 weeks under favorable conditions, but will dry out and die in a few hours when exposed to air.

Many newly hatched wireworms starve, drown, or dry out while burrowing through the soil in search of food. In Washington, Oregon, and Idaho, the larvae cause no meas-

urable damage their first year but can cause much damage their second year. In southern California larvae may cause damage as early as July of their first year.

When food, moisture, and temperature are favorable, a few larvae become fully grown within 1 year, but most require 2 to 5 years. Under unfavorable conditions they may require 6 years or more.

The full-grown larva makes a small cell 3 to 8 inches below the surface of the soil in July or August. The larva sheds its last larval skin in the cell and transforms into a white pupa. During the next 3 weeks the pupa gradually changes to an adult wireworm.

In Washington, Oregon, and Idaho most wireworms complete their life cycle in 3 years; but in southern California it may take only 2 years. Therefore, generations of wireworms usually overlap and larvae of various sizes may be present in a field.

SEASONAL MOVEMENTS IN THE SOIL

Wireworms are quite sensitive to soil conditions. Except for the Great Basin wireworm, they will not enter or remain in dry soil. As the surface of the soil cools in late summer or fall, wireworms move downward in the soil for winter; they descend as deep as 24 inches. They move upward again when the temperature at the 6-inch depth reaches 40° F. This usually is in early March in California and in late March in Washington, Oregon, and Idaho. In the Columbia Basin of Washington, however, the Great

Basin wireworm may be found near the surface of the soil late in February.

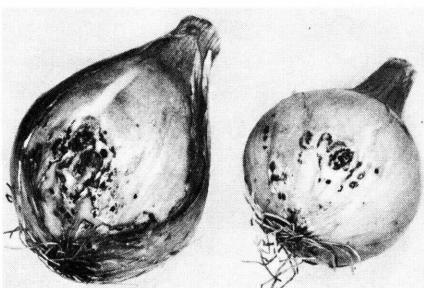


Figure 5.—Onions with holes made by wireworms.

The number of wireworms present near the soil surface gradually increases through May. Starting in June, when the surface temperature of the soil reaches 80° F., wireworms move downward again and most of them stay below the 6-inch

depth for most of the summer unless the fields are densely shaded. Some wireworms move upward again in September, for a short time, but most remain deep in the soil until the following spring.

CHEMICAL METHODS OF CONTROL

Five insecticides are recommended for control of wireworms in the West. They are ethylene dibromide, Telone, parathion, diazinon, and DDT. These insecticides have certain limitations and must be applied at the right time and in the right way to be most effective. Consider the limitations of each insecticide and decide which in-

secticide is best suited to your particular cultural program.

Ethylene dibromide and Telone are soil fumigants that kill wireworms very quickly. They are short lived, however, and become ineffective after about 3 weeks in the soil.

Parathion and diazinon also kill wireworms very quickly. They persist in the soil a little longer than the fumigants.

DDT usually requires 2 months, or longer, to kill large wireworms. It is very persistent and will prevent reinfestation by killing newly hatched wireworms for several years.

Precautions

Insecticides improperly used may be injurious to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the container label.

Keep insecticides in closed, clearly marked containers. Store them in a dry place where they will not contaminate food or feed, and where children and pets cannot reach them.

In handling any insecticide, avoid repeated and prolonged contact

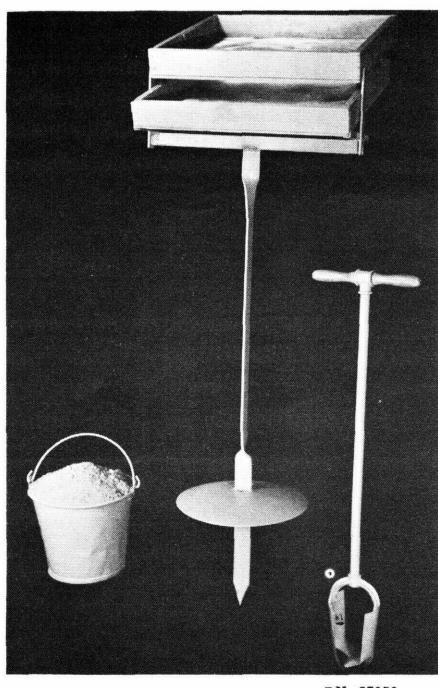


Figure 6.—Portable shaker and soil-sifting tool (center) for detecting wireworms in fields before planting.

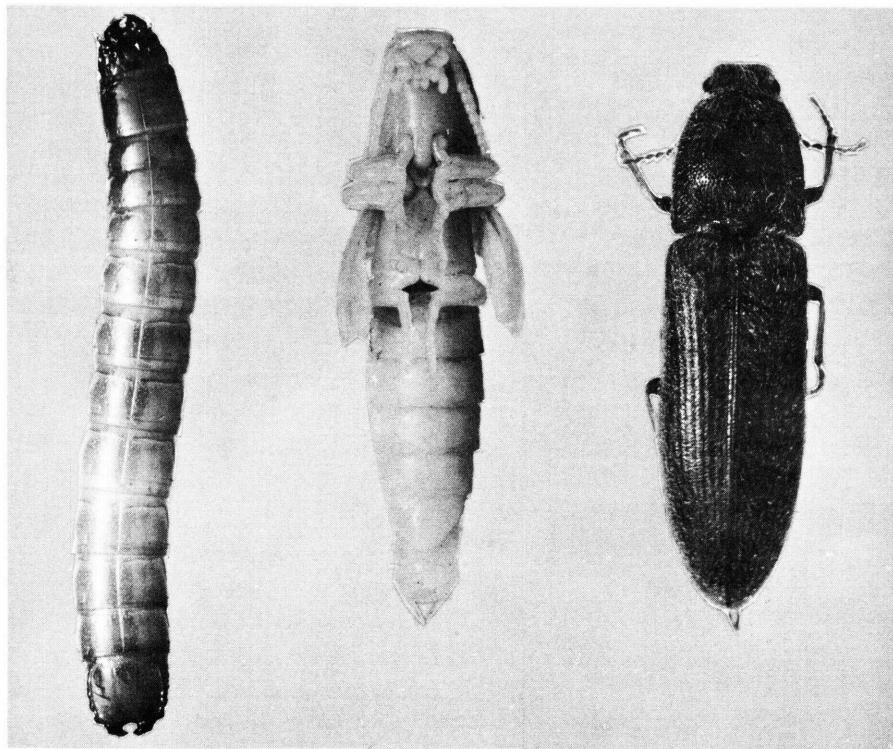
with the skin and prolonged inhalation of dusts or mists. Wash hands and face before eating or smoking.

DDT can be used safely without special protective clothing or devices if it is in the form of a dilute dust or dilute water spray. However, if it is in concentrated form it requires special precautions. Avoid spilling the liquid concentrate on your skin. Keep it out of your eyes, nose, and mouth. If you spill any on your skin or clothing, wash it off and change clothing immediately. If the concentrate gets in your eyes, rinse them with plenty of water for 15 minutes and get medical attention.

Do not feed dairy animals any root or tuber crop from soil treated with DDT.

Diazinon and ethylene dibromide can be absorbed through the skin in harmful quantities. When working with these insecticides, in any form, take the same precautions as with concentrates.

Do not transfer ethylene dibromide or Telone from one container to another in a closed room, and do not breathe their fumes. If you spill either of them on your skin, wash it off promptly with soap and water. Remove immediately clothing or shoes that have been wet with the liquid; otherwise, severe blistering may result.



BN-16110

Figure 7.—Stages of the sugarbeet wireworm: Left to right, full-grown larva, pupa, adult beetle. All enlarged.

Parathion and Telone are extremely poisonous and may cause death if swallowed, inhaled, or absorbed through the skin. They should be applied only by persons who are thoroughly familiar with their hazards and who will assume full responsibility for their safe use and comply with all precautions on the container label. After applying parathion to soil, keep all persons and animals off treated area for 48 hours.

To protect water resources, fish, and wildlife, do not contaminate lakes, streams, or ponds with insecticides. Do not clean spraying equipment or dump excess spray material near such water.

Avoid drift of DDT sprays or dusts to nearby crops or livestock. Do not repeat soil applications of DDT for at least 3 years. Do not use DDT for soil treatment on crops planted in rotation with sugarbeets.

Avoid drift of DDT, diazinon, or parathion to bee yards or to crops in bloom.

Dispose of empty containers and surplus insecticides in a sanitary land-fill dump. If this facility is not available, locate an open, isolated, level place where insecticides will not contaminate water supplies. Crush empty glass and metal containers and bury them at least 18 inches deep. Bury excess insecticides at least 18 inches deep.

Soil Fumigation

When introduced into the soil, ethylene dibromide and Telone evaporate slowly and form poison-

ous gases that spread through the soil and kill wireworms.

Do not use ethylene dibromide or Telone when the soil temperature at the 6-inch depth is below 50° F.

Ethylene dibromide.—Ethylene dibromide is usually sold as a heavy, 83-percent solution containing 12 pounds of ethylene dibromide per gallon. If your equipment will deliver 3 gallons (36 pounds of active ingredient) per acre, ethylene dibromide may be applied without dilution. If your equipment delivers more than 3 gallons per acre, add 7 gallons of any petroleum thinner for each 3 gallons of 83-percent ethylene dibromide. Mix the solution thoroughly by circulating it through your equipment, and apply it at 10 gallons per acre.

Ethylene dibromide at 36 pounds of active ingredient per acre is recommended for control of wireworms in soil to be planted to asparagus, cauliflower, cucumbers, eggplant, lettuce, melons, okra, peppers, potatoes, strawberries, or tomatoes.

Telone.—If soil is infested only with wireworms, you may apply undiluted Telone at 20 gallons per acre.

If nematodes or garden symphylans are also present, they too can be controlled with Telone. However, the rate of application may have to be increased to as much as 40 gallons per acre. Consult your county agricultural agent for specific rates of application before you apply Telone for nematodes or garden symphylans.

Telone is recommended for control of wireworms in soil to be planted to potatoes or sugarbeets.

Preparation of Soil for Fumigation

Plow the soil deep, and loosen it as much as possible before applying fumigants. If a hard plowsole or shallow caliche layer is present, use a subsoiler before plowing. Then work the surface layer of soil into seedbed condition.

The soil must be relatively free of nonrotted plant debris—for example, potato vines or cornstalks—when fumigants are applied to the soil. Nonrotted plant debris often results in poor control, because it clogs the applicator and absorbs the gases.

Fumigation Methods and Equipment

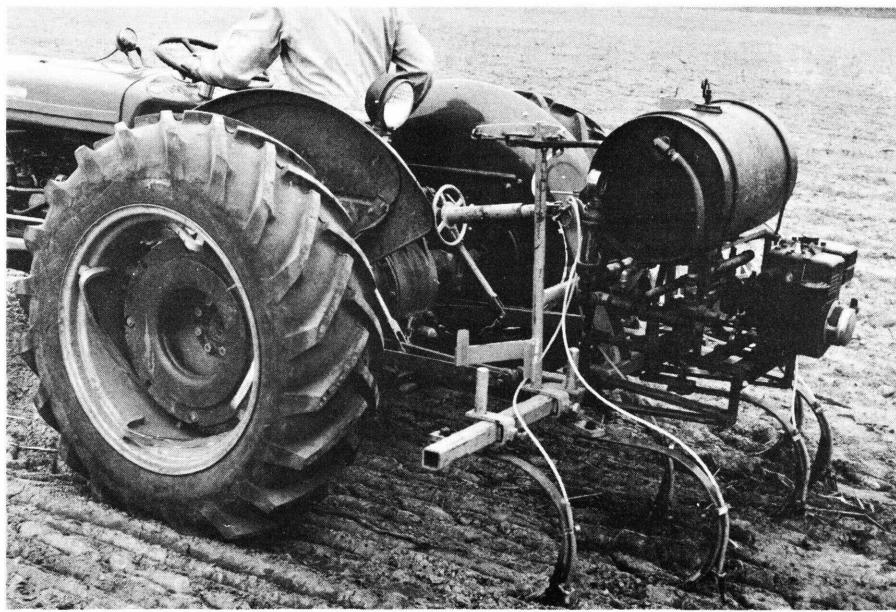
Apply fumigants when the soil at the 6-inch depth is 50° F. or above,

and neither too dry nor too wet to till properly. Treat sandy soil when it is moist; treat silt- or clay-loam soils when they are relatively dry.

Fumigants should be placed at least 8 inches deep in the soil. They may be applied with a chisel applicator (fig. 8) or plowsole applicator (fig. 9).

Pack the soil lightly immediately after treatment to seal in the fumigant. Use a roller, float, cultipacker, or similar piece of equipment for sealing in the fumigant, and do not disturb the soil for 3 weeks.

You can apply fumigants with several kinds of applicators, but the soil can be treated fastest and most uniformly with a chisel applicator (fig. 8). If you apply a mixture of



BN-27049

Figure 8.—Chisel applicator showing fumigant tank, pump, and chisels with tubes leading to the soil.



TC-7205

Figure 9.—Two-way plowsole applicator showing fumigant tank with tubes leading to the soil.

ethylene dibromide and a petroleum solvent, a bypass pipe and valve arrangement below the pump may be used to return the chemicals to the tank to insure mixing before application.

The fumigant usually is pumped under pressure through a manifold so the same amount of material can be delivered to the soil through each chisel. The fumigant is carried to the desired depth in the soil through a metal tube that is welded to the back of each chisel and is released through a spray nozzle. An applicator with 5 to 14 chisels can treat 10 to 40 acres of soil a day.

Chisels should be spaced 12 inches apart and staggered on a double tool bar. In calibrating a rig with 12-inch spacings, the number of feet you should travel while releasing 1

pint of liquid per chisel can be calculated as follows:

$$\frac{43,560}{\text{gallons per acre} \times 8} = \text{number of feet}$$

For example, if you want to apply 3 gallons of undiluted ethylene dibromide per acre, apply 1 pint per chisel for each 1,815 feet traveled. Computation is as follows:

$$\frac{43,560}{3 \times 8} = \frac{43,560}{24} = 1,815 \text{ feet}$$

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

Fumigants corrode some metals, particularly iron. It is best to use stainless steel tanks, brass fittings, and corrosion-resistant tubing on your application equipment. Drain applicators and clean them thoroughly with stove or diesel oil after each use.

Plowsole applicators (fig. 9) may be used for small fields. They can be made from a secondhand gasoline tank, some $\frac{1}{4}$ -inch copper tubing, and two or more valves. The fumigant is led by gravity from the storage tank through the tubing to the plowsole just ahead of each bottom. Needle valves regulate the flow of each outlet tube and a shut-off valve (fig. 10) is used between the tank and the tubing.

Since no pressure is applied to the fumigant in this method, 10 gallons per acre is about the smallest amount that can be delivered uniformly with accuracy. The rate of

flow must be adjusted to the width of the furrow and the speed of the tractor. The rates of flow necessary to deliver 10 gallons per acre for three furrow widths at several tractor speeds are as follows:

Tractor speed (feet per minute) ¹	Fluid ounces per minute needed to deliver 10 gallons per acre		
	12-inch furrow	14-inch furrow	16-inch furrow
250-----	7½	8½	10
300-----	9	10	12
350-----	10	12	14
400-----	12	13½	15½
450-----	13	15½	17½
500-----	14½	17	19½

¹ Eighty-eight feet per minute equals 1 mile per hour.

Soil Aeration After Fumigation

An odor may still remain in the soil 3 weeks after a fumigant has been applied. If it does, the soil must be aerated before crops may be

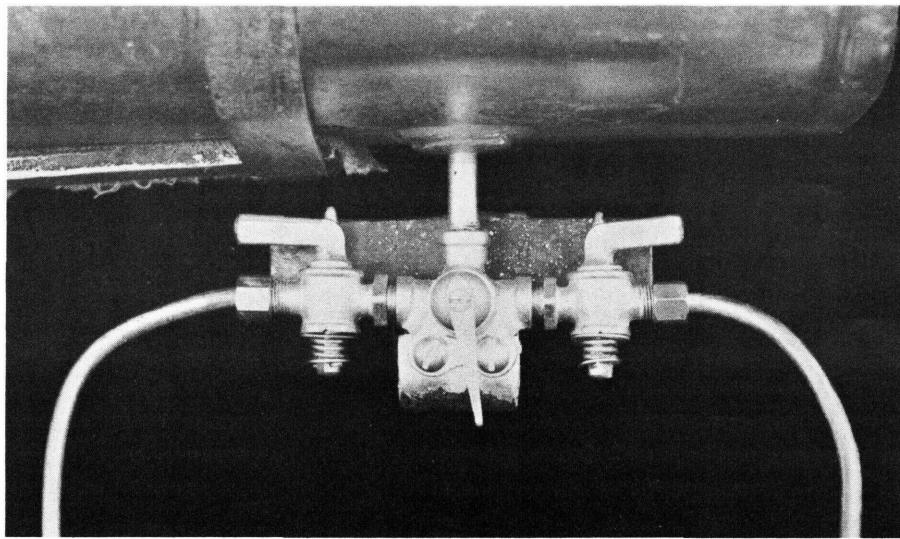


Figure 10.—Shutoff valve (center) and two needle valves used between fumigant tank and tubes of two-way plowsole applicator.

planted safely. The label on the fumigant container lists crops that require soil aeration.

To aerate the soil, break it up with a spring-tooth harrow or similar tillage implement. Do not plant until the fumigant odor has gone.

Soil Insecticides

DDT, parathion, and diazinon are available in liquid, powder, and granular forms.

DDT, in any of its forms, is very persistent in the soil and will control wireworms for several years.

Parathion and diazinon are short-lived insecticides. They remain effective against wireworms for the longest time when applied in granular form.

Timing of Applications

Parathion or diazinon should be applied in the spring, but not until the temperature of the soil at the 6-inch depth is at least 50° F.

Unlike the soil fumigants, which form gases that spread through the soil, parathion and diazinon fume very little. Therefore wireworms must come in contact with these insecticides to be killed. Although short lived, parathion or diazinon will give good control if applied when most of the wireworms are in the top 9 inches of the soil.

DDT should be applied in late summer to protect crops that are to be grown the following year. Apply DDT in July or August in the North, and at least 6 weeks before planting in the South. DDT kills wireworms slowly and only by contact. If DDT is applied in fall in

the North after most of the wireworms have moved down below the treated layer of soil, it will kill very few wireworms until they again move up into warm soil in spring.

Parathion and Diazinon

Although parathion and diazinon will control wireworms rather quickly, they are not persistent, and applications may have to be repeated every 2 or 3 years to prevent reinestation of the soil.

Diazinon is much less poisonous than parathion to man. But neither insecticide is toxic to seeds, roots, bulbs, or tubers when applied as recommended. Unlike the fumigants, they may be applied to soil immediately before planting.

Forty pounds of 10-percent parathion granules per acre are recommended for control of wireworms in soil to be planted to beans, broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, eggplant, kale, lettuce, melons, onions, peas, peppers, potatoes, rutabagas, sugarbeets, tomatoes, or turnips.

Twenty-one pounds of 14-percent diazinon granules per acre are recommended for control of wireworms in soil to be planted to beans, broccoli, cabbage, carrots, cauliflower, celery, kale, lettuce, melons, onions, peas, peppers, potatoes, sugarbeets, or tomatoes.

DDT

Soil treated with DDT will remain free of wireworms longer than soil treated with parathion or diazinon; DDT is also cheaper to use.

Apply DDT several weeks or months before planting. A single

application will usually clean up an infestation in one season (fig. 11). Reinfestation should not occur for 6 to 9 years. Do not re-treat the soil with DDT for at least 3 years or until wireworms appear in the soil.

Ten pounds of DDT per acre are recommended for control of wireworms in soil to be planted to asparagus, beans, table beets, broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, cucumbers, egg-



TC-7212, TC-7213

Figure 11.—Top, wireworm damage in untreated field of lima beans; bottom, lima bean field that was treated with DDT before planting.

plant, hops, kale, lettuce, melons, onions, peas, peppers, potatoes, rutabagas, spinach, strawberries, sweet potatoes, tomatoes, or turnips.

If 25-percent DDT granules are used, apply 40 pounds of granules per acre. If DDT sprays are used, apply 20 pounds of 50-percent wettable powder or 5 gallons of 50-percent emulsifiable concentrate (containing 2 pounds of DDT per gallon) per acre. Mix the DDT powder or liquid thoroughly with water in the spray tank and apply at least 20, but preferably 50 or more, gallons of spray per acre. (DDT wettable powder is as effective as and much cheaper than liquid DDT, but the wettable powder should be used only in sprayers that have agitators.)

Application Methods and Equipment

Insecticides should be applied evenly over the soil and then mixed thoroughly to a depth of 6 to 9 inches. Work the soil vigorously with a heavy tandem disk immediately after application. Two diskings may be better than one. The deeper and more thorough the mix, the better the control will be.

Heavy soils should be plowed before they are treated. Light, sandy soils need not be plowed if they are disked deeply and vigorously after treatment.

CULTURAL METHODS OF CONTROL

Cultural methods of wireworm control are based on the behavior of wireworms under various soil con-

ditions and farm practices. In Washington, Oregon, and Idaho, where studies were carried on for

Granulated insecticides can be applied with some kinds of dry-fertilizer spreaders or with special granular applicators. Insecticide applicators are available in several widths, and some can be mounted on a wheel-frame disk. You can apply and disk in the granules in one operation with a mounted applicator. From 30 to 40 acres can be treated in 6 to 7 hours at driving speeds of 4 to 5 miles per hour.

Granules can be applied in small fields with a crank-type grass seeder. The person operating the seeder may walk or ride in the back of a pickup truck. Parathion granules *should not* be used in a hand applicator.

If liquid or wettable powder DDT is applied with a sprayer, adjust the boom and nozzles so as to distribute the spray uniformly over the soil.

Diazinon may be applied for wireworm control on potatoes as a side dress at planting time. However, in experiments, side-dress applications were only 75 to 85 percent as effective as broadcast applications.

Do not apply insecticide granules mixed with granulated fertilizer. The insecticide granules are smaller than most fertilizer granules, and they may settle out in bags, truck beds, or applicator hoppers. This results in uneven distribution of insecticide and poor wireworm control.

over 10 years, it was found that farmers often can prevent serious wireworm damage by systematic crop rotation and certain cultural methods.

Water Use

The Great Basin wireworm disappears from soils after 3 or 4 years of irrigation. If nonsusceptible crops are grown for the first 3 years, you will not need to apply insecticides for this wireworm.

The other wireworms require moisture and live in irrigated soils or near streams. If the top 15 inches of soil in a field is allowed to remain very dry for several weeks in summer, most larvae—particularly the young ones will die.

If soil drying can be fitted into crop rotation so that heavily infested fields can be dried once every 5 or 6 years, wireworm populations can be kept below the number that will cause commercial damage. Drying of the soil to kill wireworms can best be accomplished by withholding irrigation water from good stands of alfalfa or fall grain just before it is harvested. Drying is most effective on first- and second-year wireworms in sandy- to silt-loam soils, but many larger wireworms are killed by this method.

Cultivation

Wireworm populations can be reduced by plowing infested fields in summer. Mechanical injury to the

pupae and exposure to summer heat and low humidities account for most of the mortality at this stage. If you plow fields that have been in small grain or early truck crops between July 15 and August 15, you will materially reduce the number of adult wireworms that will lay eggs the following spring.

Rotation of Crops

Wireworms increase rapidly when red clover or sweet clover is grown on infested land for more than one season. The small grains, particularly barley and wheat, also promote rapid increase in wireworms.

In contrast with clover, alfalfa usually reduces wireworm populations. It is not a favorable food for wireworms and usually creates a dry, compact soil condition that is disagreeable to wireworms. The beneficial effects of alfalfa for wireworm control can be greatly increased by omitting irrigation until after the first cutting each year, thereby preventing survival of the new-brood wireworms.

The best rotation for keeping wireworms at a low level is 3 to 4 years of alfalfa followed by 1 year of potatoes and 1 or 2 years of other truck crops, such as sugarbeets, corn, beans, or peas. The growing of truck crops continuously in the same soil may increase the number of wireworms until chemical or other cultural control measures become necessary.